Feasibility Analysis of Directional-Location Aided Routing Protocol for Vehicular Ad-hoc Networks

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***Abstract*—Vehicular Ad-hoc Network (*VANET*) is a multi-hop wireless ad-hoc network created by using mobile vehicles to transmit safety message for vehicle drivers. Since vehicles are mobile so they change their location frequently, therefore; robust data delivery is a challenging task in the *VANET*. Due to frequently network topology change characteristic, selection of a routing protocol in *VANET* is challenging task. In this paper performance of location-based routing protocols Directional-Location Aided Routing (*D-LAR*), Location-Aided Routing (*LAR*) and DIrectional Routing (*DIR*) are analyzed to decide best routing protocol for *VANET*. *LAR* protocol limits the route discovery area in the forward direction using *GPS* technology and *DIR* protocol uses direction information from the baseline drawn from the source and destination node. The *D-LAR* protocol uses concepts of the both *LAR* and *DIR* protocols. Using greedy forwarding approach *D-LAR* protocol selects next hop forwarding node in the forward direction of the communication range. Feasibility of *D-LAR* protocol has justified through simulation in *NS2* using routing metrics such as node distribution at the border area of the communication range *R*, expected one hop distance $E(N(n,r))$, expected hop counts *E(H)* between source and destination node, expected delay *E(delay)*, routing overhead and packet loss. Through simulation work, it has shown *D-LAR* protocol performs better as compared to *LAR* and *DIR* protocol.**

Keywords-VANET; DSDLAR; DLAR; LAR; SD

I. INTRODUCTION

Vehicular Ad-hoc Network (VANET) is a self-organized and decentralized wireless ad-hoc network uses mobile vehicles to transmit data packets throughout the network. VANET can be widely applied in so many fields as emergency deployments and community networking. In VANET, power and adequate storage are not an issue because VANET use vehicles as a node instead of other devices and they have sufficient energy and power for data processing and storage. One of the most important characteristics of VANET is dynamic topology [1] where vehicles move at very high speed on the road due to this they can change their network topology changes rapidly. Due to highly dynamic nature, mobility model and location prediction play a very important role in designing of data dissemination in the network.

In *VANET* all nodes are mobile therefore an efficient routing is a fundamental and challenging task. The usage of physical location information of the nodes improves the efficiency of routing techniques of *VANET*. Location information of the nodes in *VANET* mainly leads to reduce routing overhead and increases packet delivery rate [2].

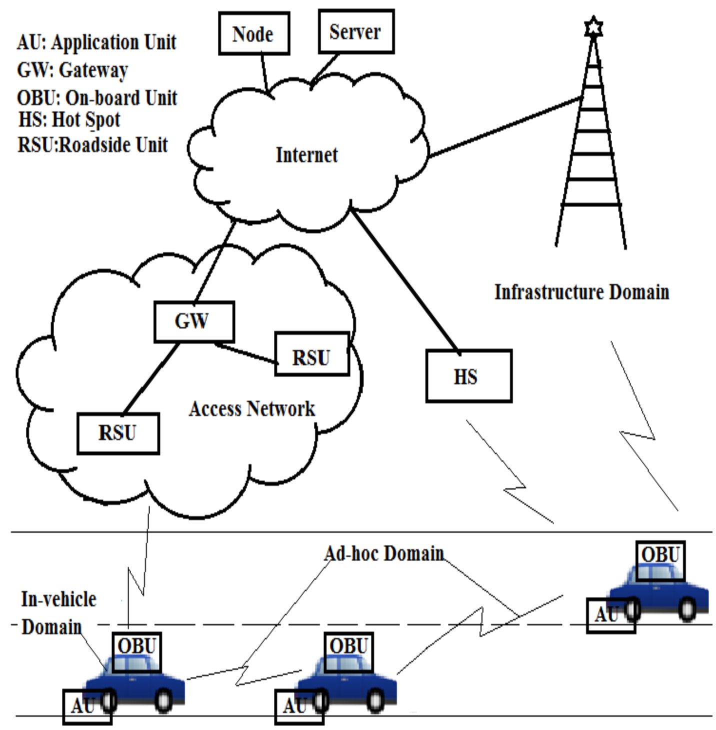

Figure1. VANET communication architecture

In VANET, routing protocols are required to transmit the data packet from a source node to destination node via a

number of intermediate nodes. The main purpose of routing protocol is to search a better route for data packet delivery to the correct destination in the network. For routing in *VANET* two types of routing protocols such as topology-based and location-based are used. Topology-based routing protocols contain information of the entire network in a routing table and location-based routing protocols contain location information of the neighbor nodes [3].

The major studies and research work done in VANET are mainly focused on traditional ad-hoc topology-based routing and location-based ad-hoc routing. Selection of routing protocols depend upon kind of network topology, therefore, it needs to study various routing protocols to select a suitable routing protocol for different kinds of the network topology in *VANET* [6]. There are some challenges and problems for the researcher to design a routing protocol for *VANET.*

1. How reliability of a routing protocol can be improved and along with the reduction of delay and retransmission of control overheads.
2. Scalability is another important issue in routing protocol due to varying network size in *VANET;* networks may be sparse or dense. In sparse network data packet must be carried by a node until the next-hop node is found in the dense network.
3. The behavior of the driver should also be considered to design the delay-bounded routing protocols since the carry-and-forward method is the main approach used for delivering the packets.
4. During designing of the routing protocol for a big city, interference caused due to the tall buildings present along the roadside should also be considered.
5. Security is one of the major issues; we need to further investigation and analyze the cooperation between inter-vehicular networks. With increasing number of vehicles on the road, the trust between these vehicles should also be sustained in order to have the smooth communication.

Day-by-day improvements in consumer's interest are ever increasing and it is an important research topic [7]. Vehicle-to-vehicle (V2V) and vehicle-to-roadside (V2R) and roadside unit-to-roadside unit (R2R) communications have become more popular in VANET. Most of the VANET research focused on urban and suburban roadways for dense network due to small inter-vehicle distance and terrain is not an important factor the fixed communication infrastructure is available [8].

Remaining parts of this paper is structured as follows: Literature survey and backgrounds on proposed DSDLAR protocol is discussed in section II. Section III presented proposed protocol in details. Section IV provides comparative simulated results of the DSDLAR with DLAR and LAR protocol. Finally, the conclusion of the paper is given in section V.

II. LITERATURE SURVEY AND BACKGROUNDS

In *VANET*, nodes are mobile vehicles they move with varying speed on the road. Menouar et al. [12] proposed a location-based routing protocol for VANET named Movement Prediction Based Routing Concept (MOPRC). This protocol predicts current location of moving vehicles on the road and mobility model depend upon the nodes lifetime in a particular place useful to determine the route. This mobility model used current position, lifetime, direction and speed of the nodes for routing [12].

In VANETs, all nodes are highly movable so VANETs requires efficient routing protocols to find out the best path in the network for better performance of the network. Due to dynamic nature of nodes, it is very difficult to deliver data items from source to destination so an efficient routing protocol can perform well in all scenarios. For routing in VANETs vehicle speed, position, and network density are challenging issues. Vehicular ad-hoc networks for a highway depends upon speed and direction of vehicles thus VANETs requires customized routing protocols for better performance. Authors Kaleem, Hussain et. al. in [13] presented direction and relative speed based routing protocol for highways using a single hop packet forwarding approach. It selects the next hop using DARS of the vehicle.

Position based routing protocols are more suitable in VANETs as compared topology-based routing protocols due to advancement and usability of GPS device. Due to limitations of GPS, systems to collect current position of the nodes depend upon the beacon interval. So there a delay occurs during collecting the current position of nodes that forces routing protocol to use inaccurate position information of nodes that lead to low throughput and high overhead. Authors Siddharth Shelly and A. V. Babu in [14] proposed a Link Reliability Based Greedy Perimeter Stateless Routing for Vehicular Ad Hoc Networks that predicts the location of neighbor nodes of the sending node using speed and direction information provided in beacon packets during the beacon interval.

In VANETs, nodes are highly mobile on the road that causes network topology frequently changes and it decreases throughput and efficiency of the routing protocol. To improve the throughput and efficiency of routing protocol position based next-hop forwarding method has recommended for the linear and nonlinear network [15, 16]. The position based routing protocol is a useful protocol in multi-hop vehicular ad-hoc networks, due to the high mobility of nodes. Selection of next-hop node is an important factor to improve routing performance in the networks. Rao and Lobiyal in [17]

proposed a protocol that selects next-hop forwarding node based on the distance and link quality between the source and next-hop node. The expected delay and throughput also estimated for the proposed method.

In order to guarantee reliable data transmission and route calculation in the context of the proactive routing protocol in [18] proposed a Link State Aware Geographic Opportunistic Routing Protocol for *VANET* for multipoint relays selection. They considerably optimized end-to-end delay from sender to receiver nodes based on an updated estimation model of link lifetime correlated with a connectivity ratio by this proposal. Indeed this new approach could be the subject of many applications, where the delay of packets delivery is critical, namely, in the aerospace domain.

In sparse VANET number of vehicles be less so route maintenance is still more complex. T. Sivakumar in [19] proposed an efficient hybrid routing protocol for sparse VANETs. This is an on-demand routing protocol with proactive route maintenance (*OPRM*) using *RSUs* that repair the route in a sparse VANET by using roadside units (*RSUs*) in place of vehicles.

H. Takagi et. al. [20] has designed a reliable routing protocol for *VANET* using *GPSR* protocol, exploiting information about link reliability during the selection of one-hop forwarding vehicles. In this routing scheme node closer to the destination node and satisfies link reliability criterion will be chosen as next forwarder node. In addition, they have given an idea for probabilistic analysis of communication link reliability for one-dimensional *VANET* and this model used for the evaluation of the modified routing scheme. The routing method discussed in this ensures that most reliable nodes chosen for forwarding data packets and building a route from source to destination.

VANET is rapidly topology change wireless ad-hoc networks play a decisive role in public safety communication and commercial application. In *VANET* nodes are highly mobile due to this network topology rapidly changes accordingly routing of data is a challenging task. Position based routing protocols are becoming popular due to advancement and availability of *GPS* devices. One of the critical issues of *VANET* is frequent path disruptions caused by the high-speed mobility of vehicle that leads to broken links, which result in low throughput and high overhead. Authors in [21] presented the use of current location information of vehicles movements such as location, direction, and speed of vehicles to predict a possible link-breakage event prior to its occurrence.

III. DESCRIPTION OF PROPOSED PROTOCOL

Directional-Location Aided Routing [12] is an improvement of Location-Aided Routing [13] protocol based on current location information of the nodes. To improve performance D-LAR protocol uses advantages of both routing protocols LAR and DIR. In D-LAR routing protocol efficiency of data delivery depends upon the current location information of the nodes obtained from the global positioning system or other location information services. After a specific time interval, each node finds own location information.

VANET is highly dynamic so to obtain correct current location information of nodes time interval should be small that turns into high communication overhead. High communication overhead in the network affects the overall network performance. Therefore, in a highly dynamic network a method is needed to find current location information and direction of nodes towards destination node with low communication overhead [12].

D-LAR protocol draws a baseline *SD* from source node *S* to destination node *D*, to select next hop forwarder node *D-LAR* routing protocol checks direction of each node from this baseline *SD*. The node closest to the baseline *SD* and moving in direction of the destination node *D* is selected as next hop forwarding node because it will give stable route in the direction of the destination node. Therefore, node selected as next hop forwarder node using this concept will reduce the average number of hop counts between source and destination node and data packet forwarding delay that increase network performance. Following figure 2 shows request zone and expected zone in the *D-LAR* protocol.

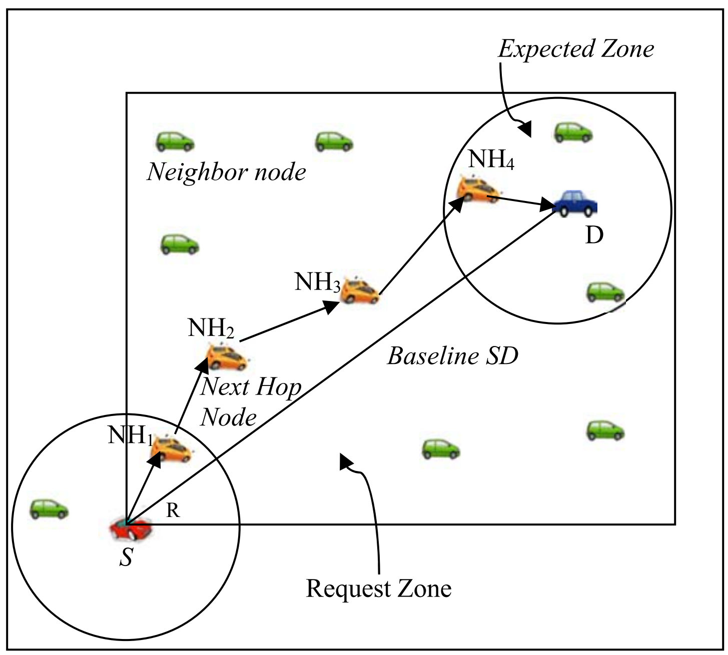

Figure 2. *D-LAR* routing scheme

Suppose, in fig. 2 current coordinate value of source node *S* and next hop node NH_1 is (S_X, Y_X) and (NH_X, NH_Y)

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respectively. When next hop node NH_1 receives a route request $RREQ$ message from the source node *S*, it calculates two values first one distance *d* between source node *S* and next hop node NH_1 and second one angle θ from baseline *SD* as follows:

$$d = \sqrt{(S_x - NH_x)^2 + (S_y - NH_y)^2} \quad (1)$$

$$\theta = tan^{-1}\left(\frac{S_y - NH_y}{S_x - NH_x}\right) \quad (2)$$

As shown in fig. 2, *S* and *D* represents source and destination node respectively. NH_1 is representing next hop node selected by the source node because it has the maximum distance from source node with the minimum angle from the baseline SD. In same fashion NH_2, NH_3 will be chosen as next hop node for further transmission of data packets in the network. Finally, next hop node NH_4 will deliver the packets to the destination node *D*. Compared to LAR and D-LAR protocol, the D-LAR protocol is more useful for a dense network environment such as city traffic scenario, where a plenty number of vehicles can make connectivity between vehicles.

A. Problem Staments

VANET comprises a large number of mobile vehicles moving randomly moving on the road. Each vehicle in VANET works as a transmitter because they participate in data transmission in the network. In *VANET*, each vehicle has a unique ID and fixed transmission range *R*. To select next hop forwarding node D-LAR uses greedy forwarding approach and selects a next hop forwarding node among the nodes at the border area of the communication range.

To achieve high network performance selection of next hop node must be appropriate because best next hop forwarding node reduces the average number of hop counts between the source and destination node and delay. This causes overall performance of the network increases. To select best next hop forwarding node *D-LAR* protocol restrict search area using the concept of expected zone and request zone. D-LAR is a location-based routing protocol useful in finding current location information and direction of nodes approaching destination.

Some routing metrics such as node distribution at the border area of the communication range *R*, expected one hop distance, expected hop counts between the source and destination node, expected delay, link lifetime and path duration are used to justify the performance of *D-LAR* protocol. Results obtained through NS2 simulation in result analysis section shown *D-LAR* protocol performs better as compared to *LAR* and *DIR* protocol.

B. Working Procedure of D-LAR Protocol

The working mechanism of the *D-LAR* protocol is as follows:

1. When source node *S* wants to communicate with a node in the network then source node recognizes request zone (*RZ*) and expected zone (*EZ*) as given in fig. 2.
2. *RZ* is a rectangular area which size is decided by source node *S*, *RZ* incorporates source node *S* and *EZ* diagonally opposite corner as shown in fig. 2.
3. Suppose, at time T_0 location of the source node *S* and destination node *D* is (X_S, Y_S) and (X_D, Y_D) and after time T_1 source node wants to communicate with the destination node *D* and knows its velocity V_D. Using details of the destination node, source node defines circular area *EZ* of radius $R=V_D(T_1-T_0)$ centered at the location (X_D, Y_D).
4. Source node *S* finds the distance of destination node *D* from its location using equation 3 and draws a baseline *SD* from itself to the destination node *D*.

$$SD = \sqrt{(X_S - X_D)^2 + (Y_S - Y_D)^2} \quad (3)$$

5. The baseline SD may either larger or smaller to the communication range R.
6. If SD > R, then source node *S* be outside of the expected zone as shown in fig. 3.

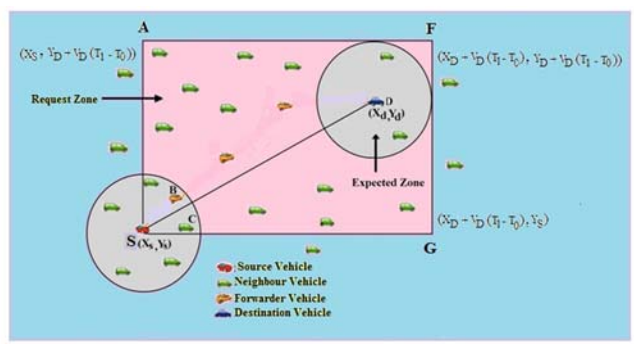

Figure 3. Source node outside of the expected zone

7. If SD < R, then source node be inside of the expected zone as shown in fig. 4.

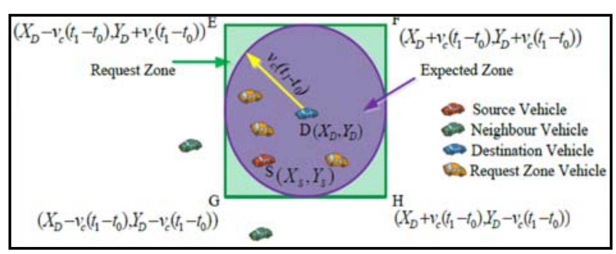

Figure 4. Source node inside the expected zone

8. Source node S initiates route discovery process by flooding route request *RREQ* message to its all neighbor nodes.
9. Source node calculates distance and angle of each neighbor nodes using following equation 4.

$$D_I = \sqrt{\left(X_{N_I} - X_S\right)^2 - \left(Y_{N_I} - Y_S\right)^2} \quad (4)$$

$$\theta_I = tan^{-1}\left(\frac{S_y - (NH_Y)_I}{S_x - (NH_X)_I}\right) \quad (5)$$

10. Source node S select a node as next hop forwarding node with maximum D_I and minimum θ_I from baseline *SD*.

C. Mathematical Analysis of D-LAR Protocol

In VANET, nodes are allowed to move within a specified area in the network at any speed, nodes are highly mobile that causes the link between nodes may be broken frequently. Therefore, to transmit data packets to the intended destination node an alternative path must be re-established immediately. In VANET, at any time either a new node can enter in the network or a node in the network can leave the network. The newly joined node in the network can establish the connection with the other nodes in the network and when a node leaves network then the connection established between nodes in the network will be broken. Due to this establishing connection between nodes and finding the average number of hop counts between the source and destination node is a challenging task. The number of nodes in the network directly affects the network performance because the higher number of nodes in the network excels probability of finding a best next hop node to forward the data packet to the intended destination node.

VANET is a highly dynamic network that causes links between nodes frequent breaks and in this situation existing path cannot deliver data packets unless an alternative path is not found by selecting a new node to forward the data packets immediately. Therefore, to verify the feasibility of *D-LAR* protocol mathematical analysis has done in the next subsection.

1. Probability of Node Distribution at Border Area of the Communication Range

The probability of node distribution at the border are of the communication range specifies the availability of nodes from that next-hop node can be selected for further data transmission. In fig. 5, it can be seen source node S would like to communicate with the destination node D in the network. The destination node D is out of the range of communication range of the source node S. Now, in this situation to complete the communication, intermediate next-hop are required. In this model, vehicle-to-vehicle (V2V) communication is considered that has no infrastructure or roadside unit (RSU) along the roadside.

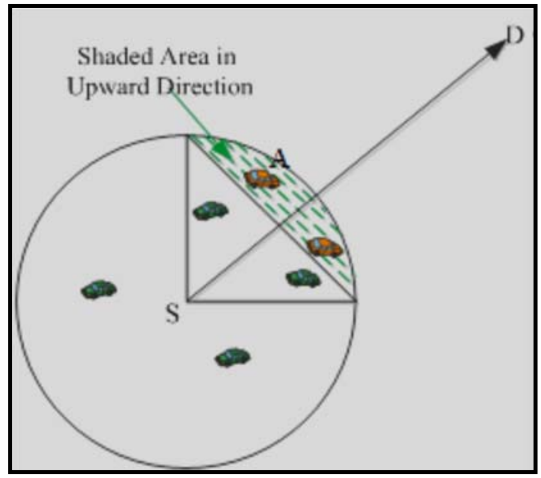

Figure 5: Distribution of nodes at the border area of the communication range.

Sensors are used on the vehicle to receive and transmit valuable traffic-related information of the network for the vehicle driver so that driver can take appropriate decision for driving the vehicle. Here transmission range of each vehicle is assumed to equal denoted by R and communication link between two vehicles depend only on the distance between them. In *VANET*, each vehicle is able to obtain won current location and velocity information with the help of *GPS* and other built-in digital roadmaps.

Suppose nodes in the network follow Poisson distribution process and K nodes arrive in the shaded area shown as in figure 3.2. The arriving nodes in the shaded area can be calculated as follows:

$$P(K) = \sum_{N=K}^{\infty} \binom{N}{K} (p)^K (1-p)^{N-K} \left(\frac{(0.352 * \rho * X^2)^N * e^{-0.352*\rho* X^2}}{N!}\right) \quad (6)$$

Therefore,

$$P(K) = \frac{(0.352 * \rho * p * X^2)^N * e^{-0.352*\rho*p* X^2}}{N!} \quad (7)$$

Now, the probability of at least K neighbor nodes consequently in the given area as shown in the above figure 4.2 can be found as follows:

$$P(K_a) = 1 - \sum_{i=0}^{K-1} \frac{(0.352 * \rho * p * X^2)^i * e^{-0.352*\rho*p* X^2}}{i!} \quad (8)$$

Now, we are able to calculate selection probability of at least one node in the shaded area within the transmission range R with the help of equation 3 as follows:

$$P = 1 - P(X = 0) \quad (9)$$

$$P = 1 - e^{-0.352*\rho*p*R^2} \tag{10}$$

2. One Hop Expected Distance

As shown in the fig. 5, node *S* represents source node and node *A* represents border node at the border area of the communication range. The border node *A* can be used as a next-hop forwarding node positioned at the maximum distance within transmission range *R*. Suppose there are *N* neighboring nodes of the source node, *S* in the forward area towards the destination node, *D*.

Let *N-1* nodes out of *N* nodes are within shaded area and N^{th} node is at maximum distance or closer to border of the sender's transmission range. Suppose, *d(S, N_I)* denotes the distance between source and I[th] node at border area of the communication range and Cumulative Distribution Function (CDF) of *d(S, N_I)* is F(r) as following:

$$F(x)= p\{ d(S, N_I) \le x \};\ x \in (-\infty, \infty)$$

$$F(x) = P[d1 \le x, d2 \le x, d3 \le x, \ldots, d_n \le x]$$

$$F(x) = \prod_{i=1}^{n} P[d_i \le x] = \left(\frac{x}{R}\right)^n \tag{11}$$

Suppose there are N nodes at the border area of the communication range, then there may be n. (n-1)/2 links between the sender node and them no longer than communication range R as N(n, R). Where N(n, R) is a random variable represents the distance of border nodes whose expected value can be expressed as:

$$E(N(n,r)) = \frac{n.(n-1)}{2} . \int_r^R F(x)dx \tag{12}$$

$$E(N(n,r)) = \frac{n.(n-1)}{2} \int_r^R \left(\frac{x}{R}\right)^n dx \tag{13}$$

$$E(N(n,r)) = \frac{n.(n-1)}{2.R^N} \left[\frac{x^{n+1}}{n+1}\right]_r^R \tag{14}$$

$$E(N(n,r)) = \frac{n.(n-1)}{2.R^N} . \left|\frac{R^{n+1} - r^{n+1}}{n+1}\right| \tag{15}$$

3. Expected Hop Counts between Source and Destination Node

In the network senario node distribution follows Poisson process, neighbour distance distribution function for a point lies in the Euclidean distance space, R^d can be defined as:

$$F(y) = 1 - P(N(b(o,y)) = 1|o) \tag{16}$$

$$F(d) = 1 - (e^{-|(N(b(o,\ y))|}) \tag{17}$$

Where $P(N(b(o,y)) = 1|o)$ is conditional probability that shows there is at least one point out of N points located in the area $b(o,x)$. Area bounded by the $b(o,x)$ can be defined as $b(o,y) = \rho R^2$. Substituting value of $(N(b(o,y))$ in the equation 1, we will get as:

$$F(y) = 1 - e^{-\rho\pi R^2} \tag{18}$$

Similarly,

$$\int(y) = \frac{d}{dR}F(y) \tag{19}$$

$$\int(y) = \frac{d}{dR}\left(1 - e^{-\rho\pi R^2}\right) \tag{20}$$

$$\int(y) = \left(2\rho\pi R . e^{-\rho\pi R^2}\right) \tag{21}$$

Thus, the probability of one hop count can be calculated as:

$$P1 = 2\rho\pi \int_0^R R . e^{-\rho\pi R^2} \tag{22}$$

Here $\rho\pi x^2$ is the area of the circle and in our proposed model, we have considered the only quarter area of the circle, so we can replace $\rho\pi R^2$ with $\frac{\rho\pi R^2}{4}$.
Now,

$$P1 = 2\rho\pi \int_0^R e^{-\frac{\rho\pi R^2}{4}} dR \tag{23}$$

Put $R^2 = y;\ 2R.dR = dy \ => \ R.dr = \frac{1}{2}dy$; Now limit will be as x=0, y=0, x=R, y=R^2. So, P1 can be written as following:

$$P1 = 2\rho\pi \int_0^y e^{-\frac{\rho\pi y}{4}} \frac{1}{2}dy \tag{24}$$

$$P1 = \rho\pi \int_0^{R^2} e^{-\frac{\rho\pi y}{4}} dy \ => P1 = 4.\left[1 - e^{-\frac{\rho\pi R^2}{4}}\right] \tag{25}$$

Here, $\frac{\rho\pi R^2}{4}$ represents the total number of nodes at the border area of the communication range so we can write P1 as follows:

$$P1 = 4.\lceil 1 - e^{-N}\rceil \tag{26}$$

Therefore, the probability of two-hop count can be obtained as follows:

$$P2 = \rho\pi \int_{R^2}^{4R^2} e^{-\frac{\rho\pi y}{4}} dy \tag{27}$$

$$P2 = \int_{R^2}^{4R^2} 4.\left[- e^{-\frac{\rho\pi y}{4}}\right]_{R^2}^{4R^2} \tag{28}$$

$$P2 = 4.\lfloor e^{-N} - e^{-4N} \rfloor . \lceil 1 - e^{-N}\rceil \tag{29}$$

For probability of the consequent hop counts the above equation can be generalized as follows:

$$P_t = 4.\lfloor e^{-N(t-1)^2} - e^{-Nt^2} \rfloor . [1 - e^{-N}]^{t-1} \tag{30}$$

From the above equation, the average number of hop counts between the source and destination node can be calculated as follows:

$$E(\mathrm{H}) = \sum_{H=1}^{t} H.P(\mathrm{t}) = \mathrm{P}_1 + 2\mathrm{P}_1 + 3\mathrm{P}_3 + 4\mathrm{P}_4 + \ldots\ldots\ldots + \mathrm{mP_m} \quad (31)$$

$$E(\mathrm{H}) = \sum_{H=1}^{t} 4H.\left[\left[\mathrm{e}^{-\mathrm{N(H-1)}^2} - \mathrm{e}^{-\mathrm{NH}^2}\right].\left[1-\mathrm{e}^{-\mathrm{N}}\right]^{(\mathrm{H}-1)}\right] \quad (32)$$

4. Expected Delay

To improve the network performance in VANET, it is required to select a suitable next-forwarder hop with the suitable path in the network to forward data packets. To minimize the delay during data transmission, suitable routing protocol such as position based routing protocol communicates packets using radio waves as earliest. Since, in VANET, roads can be used as a medium for vehicular nodes through which the packet has to be transferred, therefore, the road with maximum velocity is selected first.

During data transmission, all the routing protocols in VANET assumes that smart vehicular nodes are furnished with the computing device, sensors, digital maps, and advanced information processing tools. Digital map in the vehicle provides street and lane level map for drivers and traffic-related information such as traffic density on the road, direction of nodes, position and velocity of vehicular nodes on the roads at disparate times of the day. Total delay is the time required to transmit data packets from source node to destination node. Therefore, the expected delay between two hops can be defined as:

$$T_{delay} = Probability of atleast\ one\ node * Speed + Probability of Nonodes * Speed$$

In the sender's transmission range, the probability of at least one node can be given as:

$$\mathrm{P(x=1)} = (1-\mathrm{e}^{-\rho\mathrm{R}}) \quad (33)$$

Similarly, the probability of no node in the transmission range is:

$$\mathrm{P(x=0)} = \mathrm{e}^{-\rho\mathrm{R}} \quad (34)$$

Therefore, the expected delay can be written as follows:

$$T_{delay} = (1-e^{-\rho X}) \cdot \frac{E(k)}{S} + e^{-\rho X} \cdot \frac{E(k)}{S} \quad (35)$$

Where,

E (k) = Expected Distance between two hops
X= Communication Range of the Node
S= Speed of vehicles
ρ= Node density in the network

5. Expected Progress Distance

To find out shortest path between the source and the destination node, the expected maximum distance $E(X_{max})$ between source node and next-hop forwarding node can be used. Supposed, P_{Size} and W represent the size of the delivered packets on the network and link bandwidth respectively. The expected transmitted packets E_{TX} are used to maximize network performance in term of throughput and link quality in Wireless Ad-Hoc Network. For better performance of a wireless network the expected transmitted packets E_{TX} should be smaller for the link. Normally it is the sum of the E_{TX} value of each link along the path. But in the case of location-based Greedy forwarding method expected transmitted packets E_{TX} is measured by using periodically broadcast control message frequently sent on the network. Suppose p is the probability of successfully delivered packet and $q=1-p$ is the probability of unsuccessful to delivered packets. The successful expected transmitted packets by a node M to the next-hop forwarding node can be given as:

$$E_{TX} = \textstyle\sum_{N=1}^{\infty} M.p^M (1-p)^{M-1} \quad (36)$$

$$E_{TX} = \left(\frac{1}{(1-p)}\right) \quad (37)$$

The expected transmission time (E_{TT}) of a link can be given as follows:

$$E_{TT} = E_{TX}.\left(\frac{P_{Size}}{W}\right) \quad (38)$$

$$E_{TT} = \left(\frac{1}{(1-p)}\right).\left(\frac{P_{Size}}{W}\right) \quad (39)$$

To find out the expected progress distance of a next forwarding node we can relate both expected maximum distance $E(X_{MAX})$ of next forwarding node obtain in equation 7 and expected transmission time E_{TT} as following:

$$E_{PD} = \frac{E(X_{MAX})}{E_{TT}} \quad (40)$$

$$E_{PD} = \left(\frac{\frac{N}{R^N}\cdot\left(\frac{R^{N+1} - r^{N+1}}{N+1}\right)}{\left(\frac{1}{(1-p)}\right)\cdot\left(\frac{P_{Size}}{W}\right)}\right) \quad (41)$$

$$E_{PD} = \frac{N}{R^N}\cdot\left(\frac{R^{N+1} - r^{N+1}}{N+1}\right).\left(\frac{W.(1-p)}{P_{Size}}\right) \quad (42)$$

6. Packet Loss Rate

The packet loss rate is a ratio between the total number of delivered data packets by the source node and number of data packets received by the destination node. Suppose, source node *S* sends *M* data packets to a *CNH* nodes, but it received only M_{recv} data packets. Then the packet loss rate of a link can be given as:

$$Pkt_{loss} = \left(\frac{P_{recv}}{P_{Delivered}}\right)100\% \qquad (43)$$

IV. SIMULATION AND RESULT ANALYSIS

VANET uses the mobile vehicle as nodes to transmit data packets in the network and they can move on the road with varying speed. The simulation model of the network with variable mobile nodes 10-100 placed randomly within a 800 x 800 m^2 area. There are many different ways to measure network performance and can be modeled using Network Simulator. Performance of D-LAR protocol is evaluated using network simulator NS2 in term of nodes probability, one hop node distance, average number of hop counts, routing overhead, packet loss rate, delay and throughput. The parameters used in simulation summarized in table 1. Sample topology of NS2 is shown in fig. 6.

Table1. Used simulation parameters

Parameters	Default Values	Parameters	Default Values
Simulation area	800m X 8000m	Traffic type	CBR
Communication range	200-300m	CBR interval	0.5 s
Number of nodes	10-100	Hello interval	1 s
Node speed	5-40 m/s	Window size	15 s
Packet size	1000 bytes	Simulation time	180 s

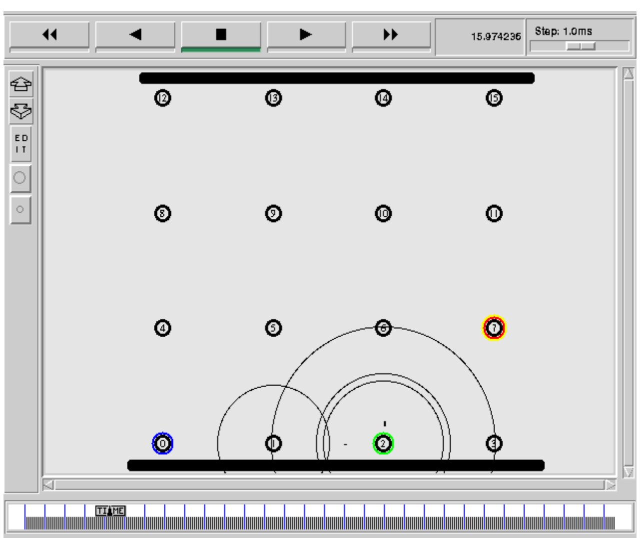

Figure 6. Sample of network topology using 16 nodes

In this simulation, any four nodes act as sender nodes with the traffic rate 0.5 seconds. As shown in fig. 3, node-0, node-1, node-2, and node-3 are the sender nodes. The receiving nodes are node-12 and node-13. As shown in fig. 5, colored circle nodes indicate the transmission of packets with the large circle in animation topology. The red colored circle node-7 indicates congestion of traffic at a time of simulation.

A. Probability of Nodes Distribution

Node distribution specifies the number of nodes available at the border area of the communication range to select next hop node for further transmission of data packets if the destination node is out of reach of the sending node. The higher number of nodes in the network increases selection probability of the best next hop node. The best next hop node increases the overall performance of the network.

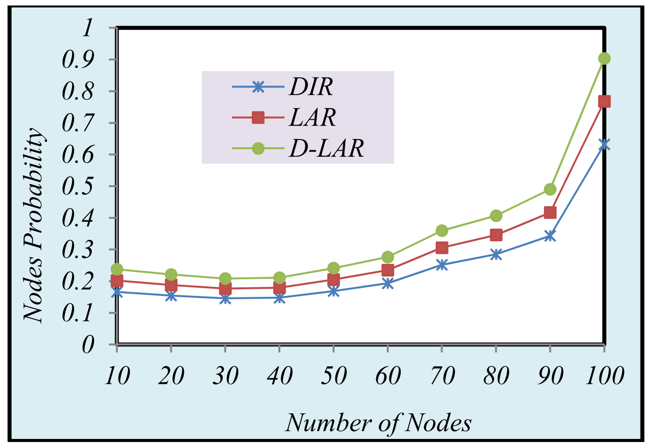

Figure 7(a). Probability of nodes vs. nodes

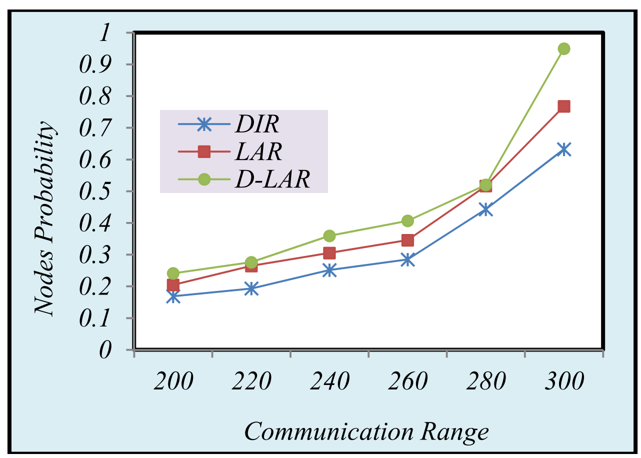

Figure 7(b). Probability of nodes vs. communication range

Fig. 7(a) and 7(b) depict the probability of nodes at the border area of the communication range vs. the number of nodes and communication range *R* of the nodes. It can be observed in both fig. 7(a) and fig. 7(b), the probability of nodes increases as the number of nodes in fig. 7(a) and communication range in fig. 7(b) increases. The higher probability of nodes increases selection probability of the best

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next hop node, the best next hop node increases overall network performances. The probability of nodes at the border area of communication range is higher in the *D-LAR* protocol so it will perform better as compared to *DIR* and *LAR* protocol.
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B. Routing Overhead

Routing overhead is a number of control packets required to discover the best route in the network for data transmission. It is an important parameter to measure the network performance; for better performance of a network control overhead should be low that causes node will consume less time to find the best route in the network.

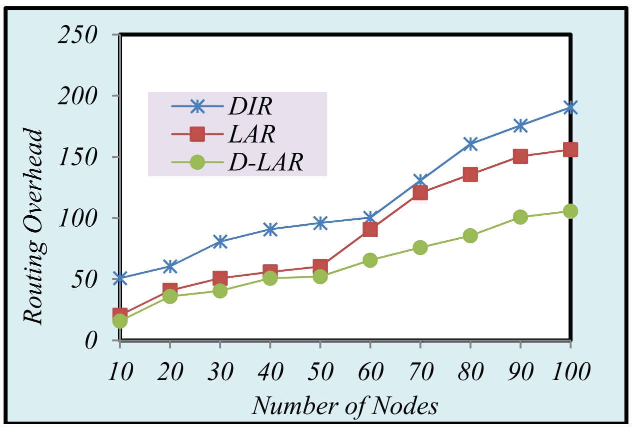

Figure 8(a). Routing overhead vs. nodes

Fig. 8(a) shows the routing overhead of *DIR, LAR* and *D-LAR* protocols vs. the number of nodes. It can be seen in figure routing overhead of each protocol increases as the number of nodes increases in the network. Reason behind this is that as the number of nodes increases the connection between sending and border nodes increases thus transferring of the routing packets between the sending and border nodes increases. Control packet overhead of routing protocol D-LAR is about 43.157% while in LAR and DIR is about 58.037% and 69.395% that are high as compared to *D-LAR* protocol.

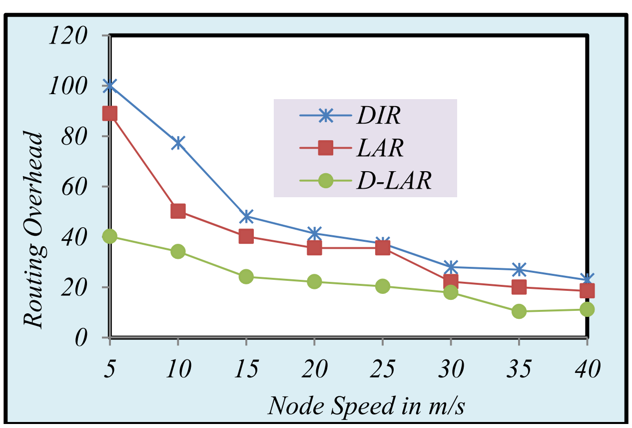

Figure 8(b). Routing overhead vs. node speed

Fig. 8(b) depicts the routing overhead vs. the nodes speed and it decreases as node speed increases. The reason behind this is that when the speed of nodes increase link duration between nodes decreases so they carry less number of control packets. Routing overhead of *D-LAR* is about 45.868% and in LAR and DIR is about 66.885% and 73.219% that are higher as compared to D-LAR protocol.

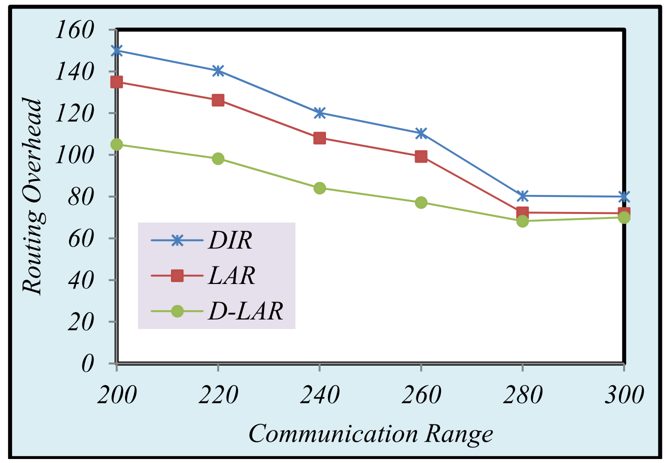

Figure 8(c). Routing overhead vs. communication Range

Fig. 8(c) shows routing overhead with respect to the communication range of nodes. It can be observed in the figure routing overhead decreases as node communication range increases. The reason behind this is that when communication range of a node increases, it requires more time for carrying and forwarding data packets from source to destination node, so the number of transmitted data packets decreases. Routing overhead of the *D-LAR* is about 75.868% and in *DIR* and *LAR* is about 84.885% and 92.219% that are higher as compared to *D-LAR* protocol.

C. Routing Protocol Packet Drop Rate

Packet drop occurs when data packets travel across the network fail to reach their destination. Usually, packet drop occurs due to poor connectivity between nodes and network congestion. Packet drop rate is an important parameter to measure network performance, for better network performance packet drop rate in the network should be low. Packet drop is measured as a percentage of packets lost with respect to packets sent across the network.

Fig. 9 (a) shows packet drop rates with varying speed of the nodes from 5 to 40 m/s. As shown in the figure, packet drop rate increases as the speed of the nodes increase reason behind this is that network stability decreases as nodes speed increases. Packet drop rate D-LAR protocol is 28.63% while in LAR and DIR is about 67.47% and 77.59%. Thus it can be said D-LAR will perform better.

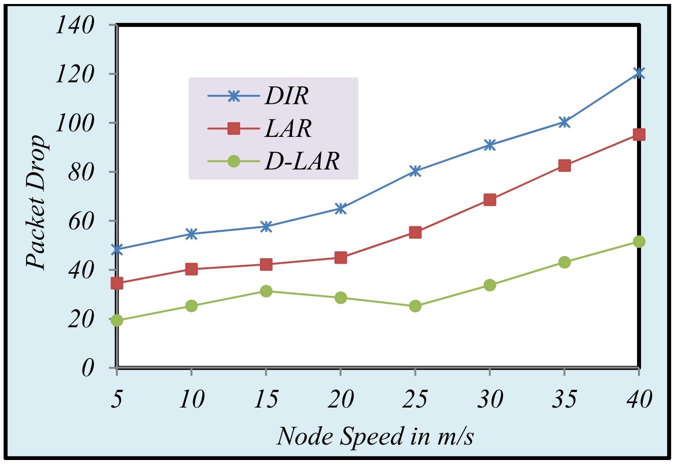

Figure 9(a). Packet drop rate vs. node speed

Fig. 9(b) depicts packet drop with varying number of nodes in the network from 200 to 300. As shown in figure packet drop rate decreases as number of nodes increases in the network because connection strength among the nodes increases as number of nodes increases in the network. Packet drop rate of routing protocol *D-LAR* is about 25.345% while in *LAR* and *DIR* is about 55.99% and 64.513% that are higher as compared to *D-LAR*.

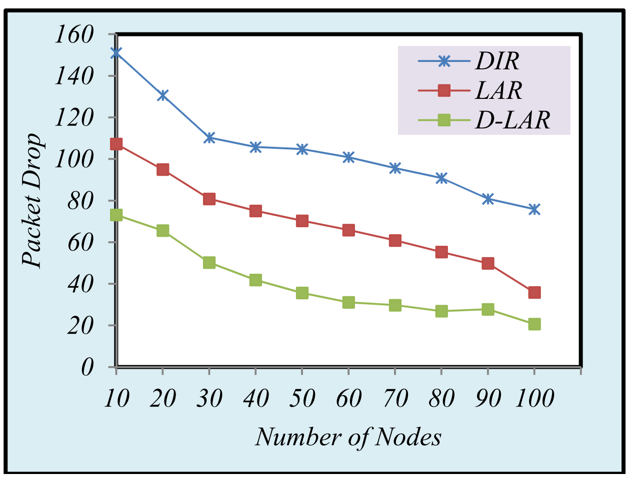

Figure 9(b). Packet drop rate vs node

D. Routing Protocol Delay

Delay is an amount of time required to transmit data packets from a node to another node in the network and it is an important parameter to measure the performance of the network. For better performance of the network and to reduce the large number of accidents delay should be low so that data packet can reach earliest at the destination.

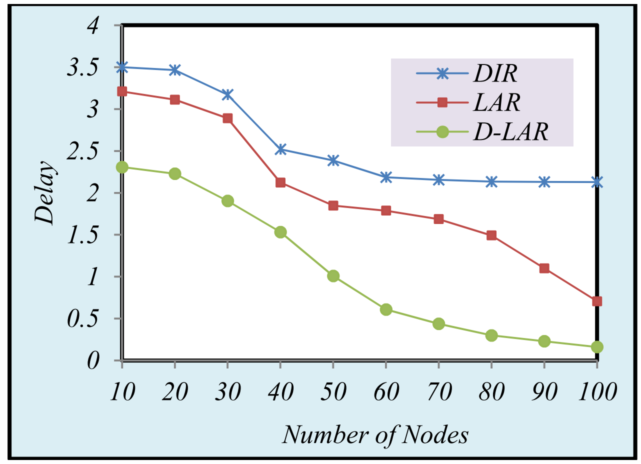

Figure 10(a). Delay vs. nodes

Fig. 10(a) shows routing protocol end-to-end delay with respect to varying nodes from 10 to 100. It can be observed in figure 10(a) routing protocol delay decreases as numbers of nodes increases. The reason behind this is that link quality among the nodes increases as nodes increases in the network. Delay in *D-LAR* routing protocol is nearly 21.31% while in other hand delays in routing protocol *LAR* and *DIR* is about 43.235% and 58.386% respectively.

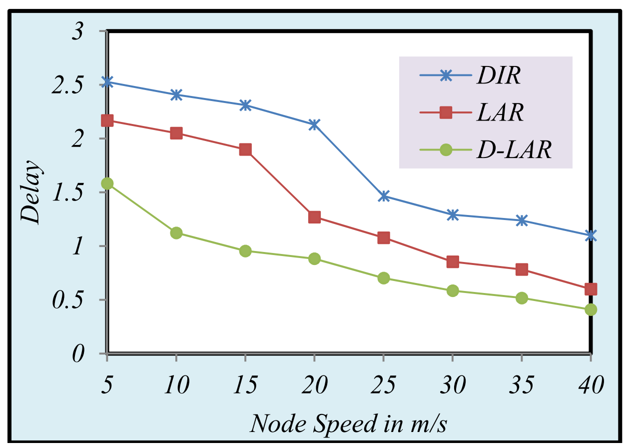

Figure 10(b). Delay vs. node speed (m/s)

Fig. 10(b) shows end-to-end delay that is and amount of time spent during successful data transmission from the source to the destination node. We can see in figure end-to-end delay declines as vehicle speed increases. The reason behind this is that the time required carrying and forwarding data packets decreases as vehicle speed increases. We can see the delay in *D-LAR* routing protocol is nearly 48.88% while in other hand delay in routing protocol *LAR* and *DIR* is about 76.51% and 83.82% respectively. For better performance of the network, the delay should be low thus we can say *D-LAR* will perform better.

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E. One Hop Distance

One hop distance is a distance between the source node to next hop node and it is an important routing metric. For better performance of the network on hop distance should be high because the higher value of one hop distance reduces the average number of hop counts between source and destination node. The minimum number of average number of hop count between the source and destination node takes less time to deliver data packets.

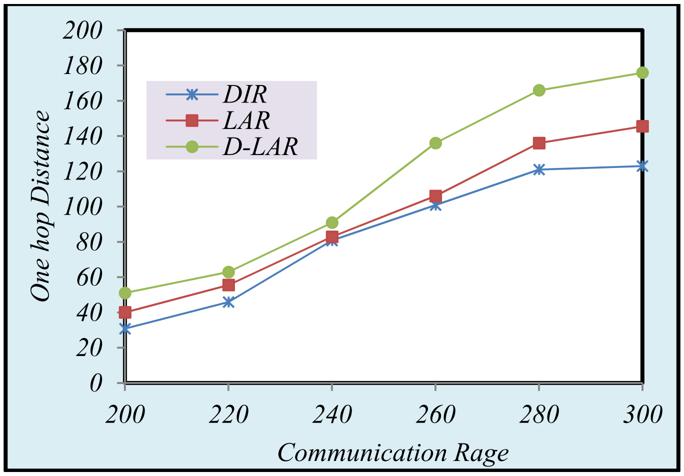

Figure 11(a). One hop distance vs. communication range

Fig. 11(a) depicts one hop distance versus communication range of nodes, it can be observed in figure one hop distance increases as communication range increases. One hop distance in the *D-LAR* protocol is higher as compared to *DIR* and *LAR* routing protocol that will perform better.

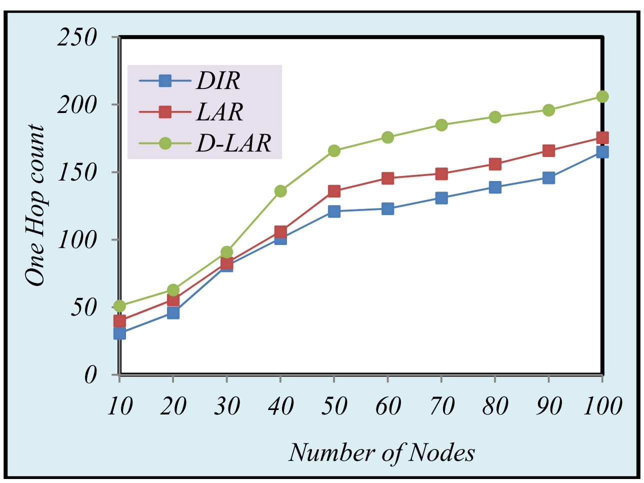

Figure 11(b). One hop distance vs. nodes

Figure 11(b) shows one hop distance with respect to varying nodes. One hop distance increases as the number of nodes increases in the network and it is higher in the *D-LAR* routing protocol as compared to *DIR* and *LAR* protocol.

F. Average Number of Hop counts

The average number of hop counts represents the number of intermediate nodes required to deliver data packets to the intended destination node. The higher number of intermediate nodes decreases network performance because it will take more time to deliver data packets at destination node.

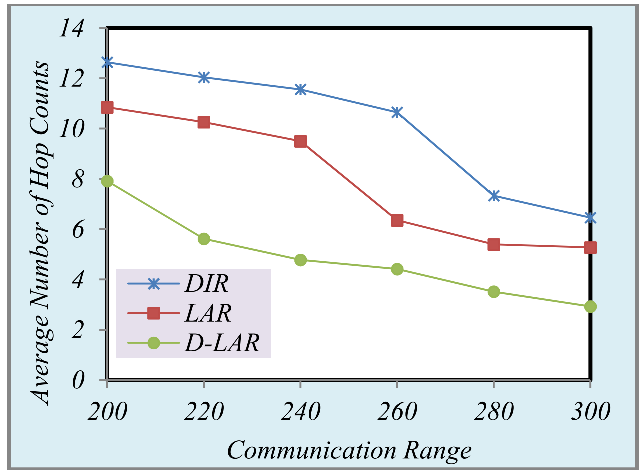

Figure 12. Average number of hop counts vs. communication range

Fig. 12 is the graphical representation of the average number of hop counts with respect to communication range. In the figure, it can be observed in figure average number of hop counts decreases as communication range increases. In *D-LAR* protocol value of the number of hop counts is lower as compared to *LAR* and *DIR* protocol.

V. CONCLUSION

Simulation results obtained through NS2 have shown the performances of the location-based routing protocols in different scenarios and with distinct performance metrics like nodes distribution, one hop distance, average number of hop counts, routing overhead, packet loss and delay. It has been found that *D-LAR* protocol performance is better in the group of location-based routing protocols.

REFERENCES

[1] Kamlesh Kumar Rana, Sachin Tripathi and Ram Shringar Rao, "Analysis of Expected Progress Distance in Vehicular Ad-hoc Network using Greedy Forwarding" 11th INDIACom; INDIACom-2017; IEEE Conference ID: 403532017 4th International Conference on "Computing for Sustainable Global Development", 01 – 03 March 2017.

[2] Ankita M. Shendurkar, Nitin R. Chopde, " A Review of Position Based Routing Protocol in Mobile Ad-Hoc Networks", International Journal of Advanced Research in Computer Engineering & Technology, Volume 3 Issue 6, June 2014.

[3] Kamlesh Kumar Rana, Sachin Tripathi and Ram Shringar Rao, " VANET: Expected Delay Analysis for Location Aided Routing (LAR) Protocol", BIJIT - BVICAM's International Journal of Information Technology, Bharati Vidyapeeth's Institute of Computer Applications and Management (BVICAM), New Delhi, India, 2016.

[4] Rahem, Ismail, Ariffidris and Aymen, "A Comparative and Analysis Study of VANET Routing Protocols", Journal of Theoretical and Applied Information Technology, ISSN: 1992-8645, Vol. 66 No.3, 31st August 2014.

[5] Kamlesh Kumar Rana, Sachin Tripathi, Ram Shringar Rao, " Analysis of Expected Hop Counts and Distance in VANETs", International Journal of Electronics, Electrical and Computational System IJEECS ISSN 2348-117X Volume 5, Issue 4 April 2016.

[6] Hongyu Tu, Lei Peng, Huiyun Li, FalinLiu, "GSPR-MV: a Routing Protocol Based on Motion Vector for VANET", ICSP, 2014.

[7] Shuai Yang, Rongxi He, Sen Li, Bin Lin, Ying Wang," An Improved Geographical Routing Protocol and its OPNET-based Simulation in VANETs", 7th International Conference on Bio Medical Engineering and Informatics,2014

[8] Rupesh and Rao, "Directional Greedy Routing Protocol (DGRP) in Mobile Ad-hoc Networks", IEEE Computer Society, International Conference on Information Technology, 2008.

[9] G. V. Rossi, K. K. Leung, and A. Gkelias, "Density-based optimal transmission for throughput enhancement in vehicular ad-hoc networks," Communications (ICC), 2015 IEEE International Conference on, pp. 6571-6576, 2015.

[10] Karp, B. and Kung, H. T., "GPSR: greedy perimeter stateless routing for wireless networks", In Proceedings of the 6th Annual International Conference on Mobile Computing and Networking, MobiCom 00, ACM, New York, NY, pp. 243-254, Agust-2000.

[11] Bouamoud Bachir, Ouacha Ali et al., "Proactive Schema Based Link Lifetime Estimation and Connectivity Ratio", Hindawi Publishing Corporation The Scientific World Journal, Volume 2014, Article ID 172014, 2014.

[12] *Menouar et al.*, "Movement Prediction-Based Routing (MOPR) Concept for Position-Based Routing in Vehicular Networks ", Conference: Vehicular Technology Conference, *2007*.

[13] Kaleem, Hussain et al, "A direction and relative speed (DARS)-based routing protocol for VANETS in a highway", Taylor Francis, Journal of the Chinese Institute of Engineers, 2014.

[14] Siddharth Shelly and A. V. Babu, "Link Reliability Based Greedy Perimeter Stateless Routing for Vehicular Ad Hoc Networks", International Journal of Vehicular Technology, Volume 2015, Article ID 921414, 2015.

[15] G. V. Rossi, K. K. Leung, and A. Gkelias, "Density-based optimal transmission for throughput enhancement in vehicular ad-hoc networks," Communications (ICC), 2015 IEEE International Conference on, pp. 6571-6576, 2015.

[16] K. Prasanth, K.Duraiswamy, K.Jayasudha, C.Chandrasekar, "Improved packet forwarding approach in vehicular ad-hoc networks using RDGR algorithm", International Journal of Next Generation Network, Vol.2, No.1, March 2010

[17] R. S. Rao and D. K. Lobiyal, " Throughput and delay analysis of next-hop forwarding method for nonlinear vehicular ad-hoc networks", International Journal of Ad-Hoc Networking System, Vol.2, No.2, April 2012.

[18] Cai et al.," LSGO: Link State aware Geographic Opportunistic routing protocol for VANETs", EURASIP Journal on Wireless Communications and Networking, Springer Open journal 2014.

[19] T. Sivakumar , "OPRM: an efficient hybrid routing protocol for sparse VANETs", International Journal Computer Aplications in Technology, Vol. 51, No. 2, 2015.

[20] H. Takagi and L. Kleinrock, "Optimal Transmission range for randomly distributed packet radio terminals" IEEE Transactions on Communications 32 (3), pp. 246–257, 1984.

[21]. Boukerche, Oliveira et. al., "Vehicular ad-hoc networks: A new challenge for localization-based systems", Computer Communication, Amsterdam: Elsevier, 2008.

[22] Chi Trung Ngo, Hoon Oh, "A Link Quality Prediction Metric for Location based Routing Protocols under Shadowing and Fading Effects in Vehicular Ad Hoc Networks", Procedia Computer Science, Volume 34, Pages 565-570, 2014.